



Defense Energy Support Center

**Defense Energy Support Center**

**Product  
Technology  
&  
Standardization  
Division**

## **FUEL ACADEMY**

# **Ultra Low Sulfur Diesel (ULSD) Fuel Tutorial**





# Learning Objectives



*You should learn....*

- The definition of ULSD (Ultra Low Sulfur Diesel Fuel)
- The role of ULSD as a part of EPA regulations (special exceptions for Alaska, California)
- How is ULSD generically produced?
- The advantages and disadvantages of using ULSD
- Schedule for ULSD introduction in the U.S.
- Logistics strategies (Tank Preparation)



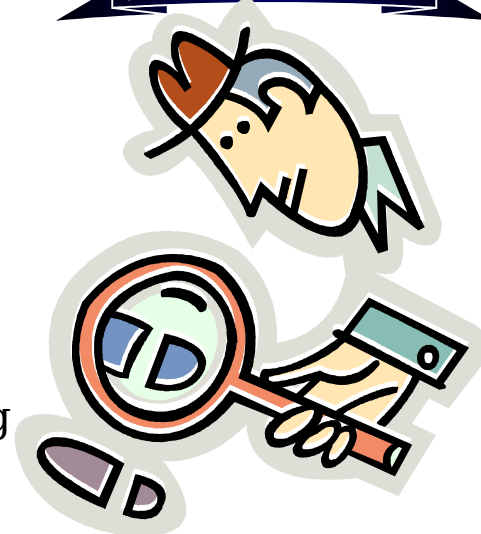


# What is ULSD?

## Ultra Low Sulfur Diesel

Formally named **S15** by the American Society for Testing and Materials (ASTM)

Diesel Fuel with sulfur content not exceeding  
**15 ppm** (parts per million)



### Designation

### Max. Sulfur Content

<b>Note:</b> S15	➡	15 ppm
S500	➡	500 ppm
S5000	➡	5000ppm

Defined by ASTM Std D975, Table 1

Designations also apply to Canadian diesel market



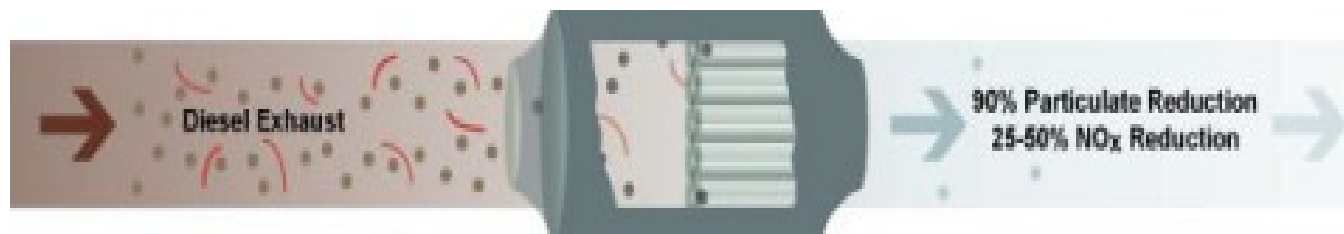


# Why is ULSD necessary?



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ULSD is necessary because.....



- The primary reason for introducing ULSD is to reduce exhaust emissions of particulate matter (90%), and nitrogen oxides by more than 25-50%. The EPA estimates that there will be significant health benefits from stricter emission standards and that these benefits will increase over time.
- 2007 Diesel Engines will have new sulfur-sensitive emission control equipment using fuel other than ULSD can damage these emission control systems.

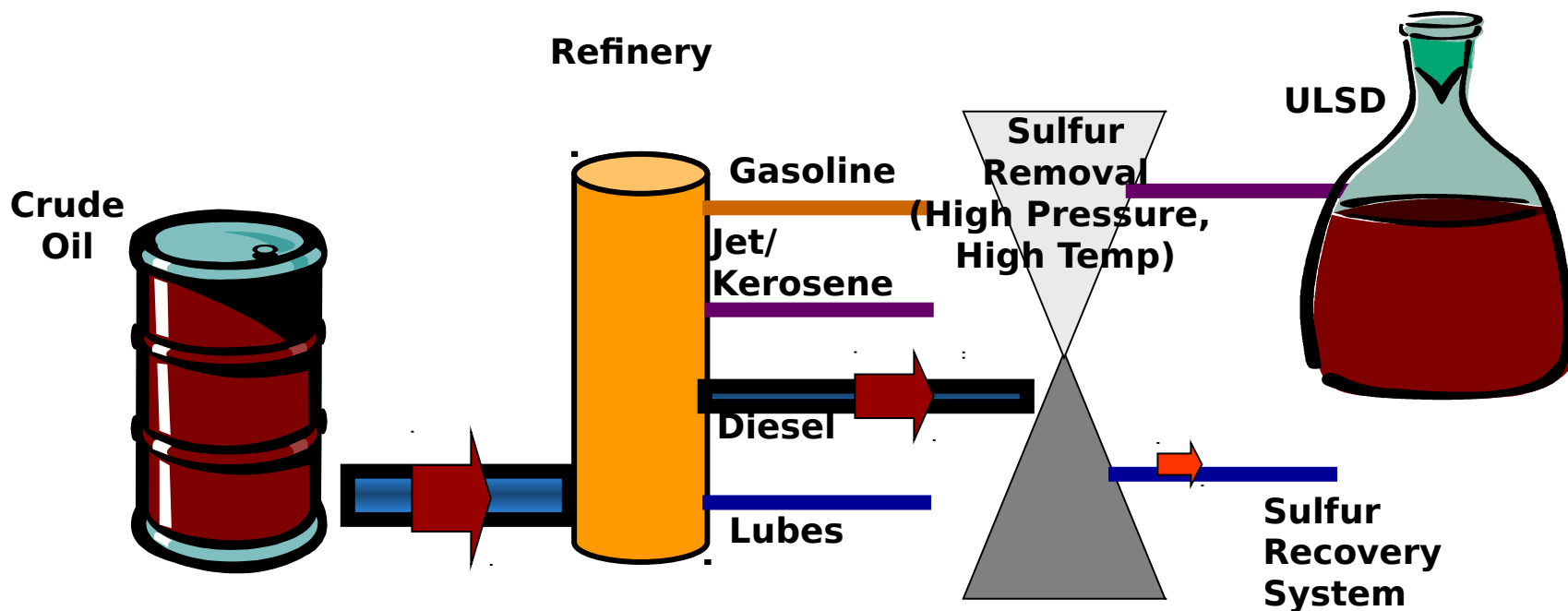




# Generic ULSD Processing



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# Key Advantages of ULSD



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- ✓ **Complies with EPA Regulation “Control of Air Pollution for New Motor Vehicles: Heavy-duty engine and vehicle standards and highway diesel fuel sulfur control requirements (40 CFR Parts 69, 80, 86 January 18, 2001)”**
- ✓ **Compatible with all diesel engines**
- ✓ **Motor vehicle emissions reduced. Particulate emissions reduced by 90% and NOx emissions reduced up to 50%**
- ✓ **Helps promote cleaner air**





# Present Limitations of ULSD Fuel



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- X **Potentially higher cost**
- X **Limited Availability**
- X **Potential fuel leaks from failing engine seals**
- X **Cold weather concerns**
- X **Limited distribution and Retail sales sites**





# Effective Dates for “Highway” ULSD



<u>Logistical Point</u>	<u>Readiness Milestone</u>	<u>U.S.</u>	<u>California</u>
Refiners/Importers	Produce/import at least 80% ULSD for on highway use	<b>6/1/2006</b>	
	<b>Produce/import 100% ULSD for on highway use</b>	<b>6/1/2010</b>	<b>6/1/2006</b>
<b>Downstream from Refineries through Fuel Terminals</b>	<b>Facilities that choose to carry ULSD must meet 15 ppm sulfur specification</b>	<b>9/1/2006</b>	
	<b>All highway diesel must be ULSD</b>	<b>10/1/2010</b>	<b>7/15/2006</b>
<b>Retail Outlets</b>	<b>Facilities that choose to dispense ULSD must meet 15 ppm sulfur specification</b>	<b>10/15/2006</b>	
	<b>All highway diesel must be ULSD</b> <b>Highway Diesel = Diesel Used for Motor Vehicles</b>	<b>12/1/2010</b>	<b>9/1/2006</b>

Reference: [www.clean-diesel.org](http://www.clean-diesel.org)







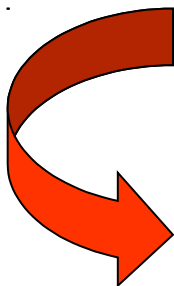
# The California Factor



**Why is California different?**



**Individual states are allowed to adopt more stringent requirements than the federal law!**



**California law makers adopted tighter scheduled deployments of ULSD at the terminal and retail levels!!!**





# The Alaska Factor



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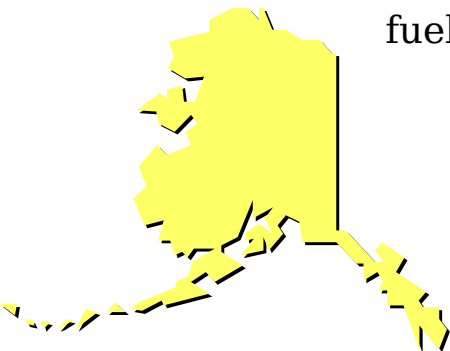


## Why is Alaska different?

- Until 2010, rural areas of Alaska will be able to continue use high sulfur (>500ppm) content diesel for all uses; and thus will not face the unnecessary burden of trying to carry multiple grades of fuel.



- All areas of Alaska, including both urban and rural, will begin transitioning both highway and NRLM (Non-Road Locomotive, Marine) diesel fuel to 15 ppm sulfur content diesel fuel at the same time: June 1, 2010.



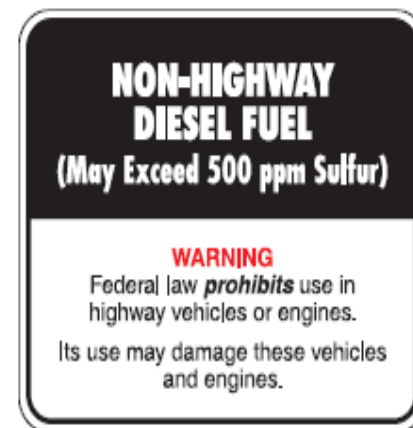
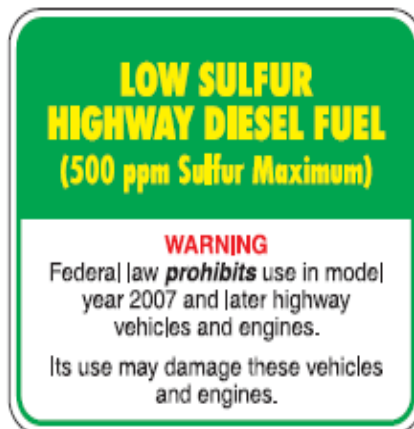
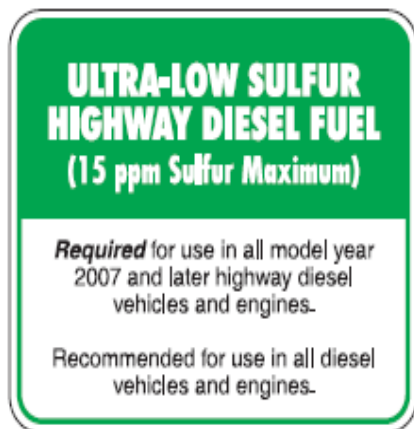


# ULSD Label Schemes



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**What are the dispenser pump labeling requirements?**



- Titles of all labels (e.g., Low Sulfur Highway Diesel Fuel) are in 24-point type, Sulfur Level Cap Designations (e.g., [500 ppm Sulfur Maximum]) are in 20-point type, and all other required language is in 14-point type as approved by the EPA.
- Green is chosen as the background for the first two labels because of its strong association with diesel in the gasoline service station network.
- Labels shall be on the upper two-thirds of the pump in a location where they are clearly visible.
- Pumps must be labeled by June 1, 2006.

**Reference: EPA.gov**





# Diesel Labels and Dyes



- ◆ **“ULTRA LOW SULFUR **ON-HIGHWAY** DIESEL FUEL”** – **Undyed**, 15 ppm (0.0015%) max sulfur
- ◆ **“ULTRA-LOW SULFUR NON-HIGHWAY DIESEL FUEL”** – **Red Dyed**, 15 ppm max sulfur
- ◆ **“LOW SULFUR NON-HIGHWAY DIESEL”** – **Undyed**, 500 ppm (0.05%) max sulfur
- ◆ **“HIGH-SULFUR NON-HIGHWAY DIESEL FUEL”**– **Red Dyed**, 5000 ppm (0.5%) max sulfur
- ◆ **“HEATING OIL”** – **Red** & **Yellow** Dyed, 5000 ppm (0.5%) max sulfur

NOTES: (1) To differentiate between heating oil and On-road/Off-road diesel fuel, heating oil will be dyed with Solvent Yellow 124 (in addition to red for tax purposes)

(2) Dyed fuel is “un-taxed” fuel



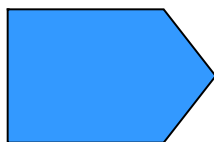


# Contamination During Transport

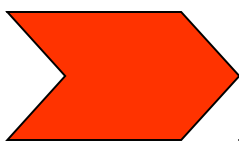


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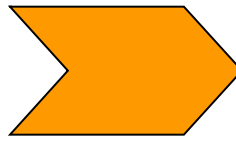
**Sulfur content tends to increase as fuel moves through the transportation process**



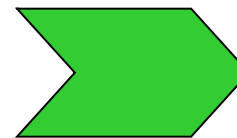
**Refinery**



**Pipeline**



**Terminal**



**Truck  
Transport To  
Retail  
Disbursement**

## An Example of Contamination

**Fuel Type                      Amt of non-ULSD added to 7500 gallons of ULSD**

<b>Contamination Amount</b>	<b>7 Gallons</b>	<b>37 Gallons</b>	<b>75 Gallons</b>
<b>500 ppm Diesel Fuel (LSD or S500)</b>	<b>+0.5 ppm</b>	<b>+2.5 ppm</b>	<b>+5 ppm</b>
<b>3000 ppm Jet Fuel</b>	<b>+3 ppm</b>	<b>+15 ppm</b>	<b>+30 ppm</b>
<b>5000 ppm Heating Oil</b>	<b>+5 ppm</b>	<b>+25 ppm</b>	<b>+50 ppm</b>

**Note:  
Small amounts of higher Sulfur product may contaminate ULSD**

**\* Above table should not be used for blending ratios!**





# Earlier Model Vehicles



**Can ULSD be used in 2006 and earlier engine models?**



**ULSD (S15) is compatible with 2006 and earlier model diesel engines!!**



**Note: ULSD may affect fuel seals on engines; proactive maintenance should be used**



# ULSD Vehicles



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**Which motor vehicles are required to use S15 (ULSD)?**

**All on-highway heavy-duty diesel vehicles manufactured in model year 2007 and later will be required to use S15 (ULSD)**



**These vehicles will be forbidden to use diesel fuel with sulfur content greater than 15 ppm (parts per million).**

**Also**

**Most 2007 light-duty and passenger car vehicles require S15 (ULSD).**

**Vehicles not specifically designed for use With S15 (ULSD) may use either S15 or S 500 (500 ppm)**



**Note: Please consult your vehicle "User Manual"**



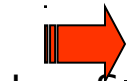


# ULSD and Biodiesel



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**Can Ultra-Low Sulfur Diesel (ULSD) fuels be used as the diesel fuel component in bio-diesel blends such as B-2, B-20, B-xx?**



Low Sulfur

Technically the diesel portion of bio-diesel blends can be either Diesel or Ultra-Low Sulfur Diesel.



the

Some DESC contracts have been changed to allow only ULSD as the diesel fuel component of biodiesel blends.



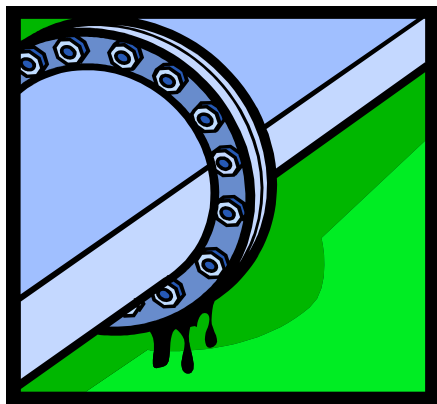


# Engine Fuel Seals



Some early users of ULSD have experienced leaks.....

This problem is not exclusive to one engine type, one fuel type, or one geographic region. It can affect some engines that are older than ten years, but some newer ones have experienced the problem as well.



Seals in some vehicles may fail while similar seals in other vehicles using the same fuel may not.

Past experience indicates that the common denominator appears to be nitrile rubber (Buna N) seals that have seen long service at high temperatures.

High temperatures have a tendency to accelerate seal aging. The reduction in sulfur content is not responsible for the problem.





# Changes in Fuel Properties



Fuel property changes moving to S15 (ULSD):

## Lubricity

- The reduction in Sulfur processing reduces lubricity (the ability to protect the parts of the engine's fuel injection system from wear)
- Fuel additives can be used to improve lubricity
- ASTM adopted a lubricity specification for diesel fuels, effective Jan 2005

## Energy Content

- In general, the processing required to reduce sulfur to 15 ppm also reduces the aromatics content and density of diesel fuel, resulting in a reduction in energy content (BTU/gal).
- The expected reduction in energy content is on the order of 1% and may affect fuel mileage.

## Cetane Number



- Processing reduces aromatics content which increases Cetane Number
- A higher Cetane number indicates a shorter ignition lag and cleaner burning fuel



# Cold Weather Concerns

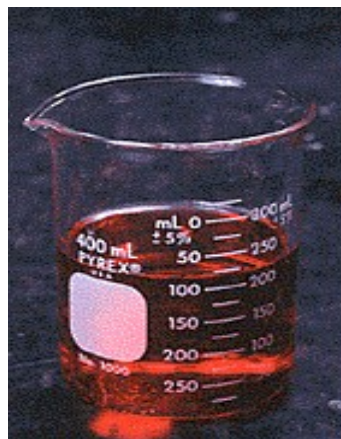


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**In cold weather, traditional diesel (LSD) can have cold weather handling issues (due to a high Cloud Point)**

**The cloud point of ULSD is higher than conventional Diesel fuel.**

**ULSD may require additives or heated storage tanks when Ambient temperature gets very low**



**Note:** Cloud point is an extremely important parameter because it directly impacts truck operability and fuel economy. It is recommended that the fuel cloud point be colder (6°F is often quoted) than the lowest anticipated ambient temperature at which the truck is expected to operate; otherwise, there is a significant risk of filter plugging and downtime.





# Blending in Cold Weather



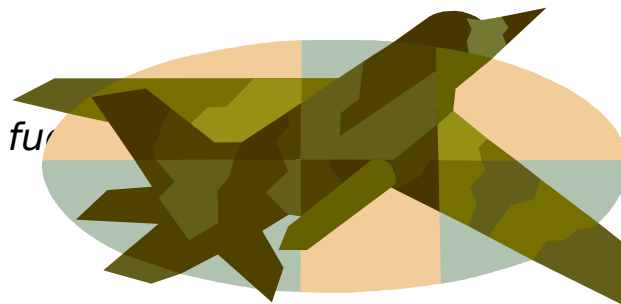
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**Can jet fuels (JP-8, Jet-A or Jet A-1) be used to improve ULSD cold weather performance?**

*No. Jet fuel sulfur specifications are higher than the allowed 15 ppm and cannot be used for improving ULSD low temperature performance.*

*Only fuels like ultra low sulfur kerosene (No. 1 diesel with no more than 15 ppm sulfur) may be blended with ULSD fuel to improve cold weather performance. With so many kerosene formulations on the market, care must be taken to select kerosene with a maximum of 15 ppm sulfur.*

*Blend rates will remain the same as with Low Sulfur Diesel fuel.*





# Be Compliant!!!



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- (1) Update the quality control program to accommodate ULSD**
- (2) Ensure all storage tanks and dispensers are properly labeled**
- (3) Examine ALL product transfer documents to ensure proper receipt**
- (4) Be sure that fuel is dispensed into the appropriate tank**
- (5) Save your product transfer documents as required by direction**
- (6) Sample and test product inventory for sulfur compliance routinely**
- (7) If an improper fuel delivery occurs, stop issuance and contact the Fuel Management Office and Service Control Points.**



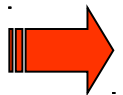


# Tank Preparation for ULSD

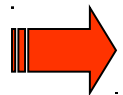


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**How can I prepare my tanks to receive ULSD fuel with current stocks & inventory levels?**



**Cleaning **NOT** required for conversion of standard diesel fuel to ULSD**



**Conversion from 500 ppm (LSD) to 15 ppm ULSD **can** be performed in conjunction with regularly scheduled cleaning for convenience**



**Reference: DESC Quality Operations Divisions (DESC-BQ) letter, "Conversion of Tank for ULSD Use"**



# Tank Preparation for ULSD (2)

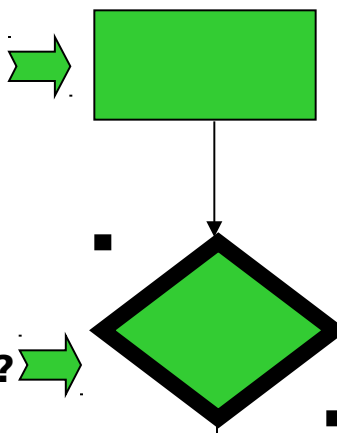


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**Conversion of storage tanks, when previous 5 refills are ULSD**

**Take all level sample from storage tank and submit for testing**

**Test results 15ppm or lower?**



**Yes**

- Regrade the fuel 15 ppm ULSD
- Modify contract Receive ULSD

**No (>15 ppm)**

**Follow procedure On following pages**





# Upgrading LSD Tanks for ULSD



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**Upgrading tanks to ULSD from LSD (500 ppm)**



**Modify contract to buy ULSD**



**Draw tank down to lowest point  
(no more than 10% of tank capacity)**



**Strip down tank bottoms (if feasible)**



**Receive ULSD with qualified paperwork  
before off-loading**



**Reference: DESC Quality Operations Divisions (DESC-BQ) letter, “Conversion of Tank for ULSD Use”**





# Upgrading LSD Tanks for ULSD (2)



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## Upgrading tanks to ULSD from LSD (500 ppm)



**At completion of receipts, do all level sample**



**If tank was stripped, test after first tank complete fill**



**If tank results are initially 15ppm or lower, begin Working with DESC-BQ for formal upgrade before Issuing ULSD**



**After notification of contract modification, regrade All LSD in storage tank to ULSD and begin ordering ULSD from contractor.**



**If test results > 15ppm, repeat above steps until 15 ppm limit is reached**



**Use above procedure for all LSD tanks**



**Reference: DESC Quality Operations Divisions (DESC-BQ) letter, "Conversion of Tank for ULSD Use"**



# Upgrading LSD Tanks for ULSD (3)



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## Large Bulk Tanks.....



**Several receipts may be required to reach the desired 15 ppm sulfur limit**



**Contact Major Command/Service Technical Office and DESC-BQ to formulate plan with minimum operational impact.**



**Reference: DESC Quality Operations Divisions (DESC-BQ) letter, "Conversion of Tank for ULSD Use"**



# Reference Material



## **ULSD Refinery Readiness**

**<http://www.epa.gov/otaq/highway-diesel/compliance.htm#reports>**

## **General ULSD Materials**

**[www.clean-diesel.org](http://www.clean-diesel.org)**

**[www.epa.gov](http://www.epa.gov)**

**[www.eia.doe.gov/oiaf/servicerpt/ulsd/](http://www.eia.doe.gov/oiaf/servicerpt/ulsd/)**

**[www.cleanenergy.org](http://www.cleanenergy.org)**





# Learning Objectives



*What you should now know.....*

- The definition of ULSD (Ultra Low Sulfur Diesel Fuel)
- The role of ULSD as a part of EPA regulations (special exceptions for Alaska, California)
- How is ULSD generically produced?
- The advantages and disadvantages of using ULSD
- Schedule for ULSD introduction in the U.S.
- Deployment and logistics strategies





# Frequently Asked Questions



1. What is S15 (ULSD)?
2. When is S15 (ULSD) required to be produced and sold?
3. Why is the timeline for California and Alaska different than the rest of the U.S.?
4. Where is S15 (ULSD) required to be used?
5. Why is S15 (ULSD) necessary?
6. What are the pump labeling requirements?
7. Where can I get additional information on S15 (ULSD)?





# Frequently Asked Questions



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8. Which vehicles are required to use S15 (ULSD)?
9. Can S15 (ULSD) fuel be used in 2006 and earlier model engines?
10. How will diesel fuel properties, other than sulfur, change with S15 (ULSD)?
11. How will S15 (ULSD) affect my fuel system seals?
12. How will the retail consumer know which diesel product they are putting in their vehicle?
13. Will S15 have a different color than the current S500 diesel fuel?





# Frequently Asked Questions



- 14. Question. Can Ultra-Low Sulfur Diesel (ULSD) fuels be used as the diesel fuel component in bio-diesel blends such as B-2, B-20, B-xx?**
- 15. Question. Can jet fuels (JP-8, Jet-A or Jet A-1) be used to improve ULSD cold weather performance?**





# Frequently Asked Questions



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## 16. How will ULSD fuel affect air quality?

*Answer. ULSD fuel will enable the use of cleaner technology diesel engines and vehicles with advanced emissions control devices, resulting in significantly improved air quality. Annual emission reductions will be equivalent to removing the pollution from more than 90 percent of today's trucks and buses, when the current heavy-duty vehicle fleet has been completely replaced in 2030.*

## 17. How will ULSD fuel affect the power and fuel economy of existing diesel cars, trucks and non-road engines and equipment?

*Answer. Under typical operating conditions, there should be no noticeable impact on overall power using ULSD fuel.\* Fuel economy may be reduced slightly because the process that removes sulfur also can reduce the energy content of the fuel.\**







# Frequently Asked Questions



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**18. *What are the penalties for failing to comply with EPA's ULSD fuel standards?***

*Answer: The new standards provide strong incentives for suppliers to provide the proper ULSD fuel formulation. Civil penalties of up to \$32,500 per violation per day can be assessed for non-compliance with EPA's ULSD fuel standards, or for misrepresentation of the sulfur level of diesel fuel. For more information about ULSD fuel standards and implementation, visit:  
U.S. Environmental Protection Agency*

**19. *What happens if you receive a non-conforming shipment of ULSD?***

*Answer: Contact your Service Control Point, DESC-P, and DESC-BQ for disposition instructions.*

